Claims

What is Claimed is:

1. A method of detecting an abnormal situation associated with a process plant, comprising:

receiving measured data pertaining to a process parameter sensed by at least one sensor device associated with the process plant;

determining one or more statistical measures associated with the process parameter using the measured data; and

using the one or more statistical measures associated with the process parameter to detect an abnormal situation within the process plant.

2. The method of claim 1, further including the processing the measured data to produce processed data and wherein determining the one or more statistical measures associated with the process parameter includes determining the one or more statistical measures using the processed data.

3. The method of claim 1, further including determining a block length for use in computing the one or more statistical measures from the measured data.

4. The method of claim 3, wherein determining the block length includes collecting a number of first data points for the process parameter, determining a frequency component of the process parameter based on the collected number of first data points, determining a dominant system time constant from the frequency component and setting the block length based on the dominant system time constant.

5. The method of claim 4, wherein determining the frequency component includes performing a Fourier Transform on the collected number of first data points.

6. The method of claim 4, wherein setting the block length includes selecting the block length as a multiple of the dominant system time constant.

7. The method of claim 4, wherein determining the dominant system time constant includes determining a corner frequency from the frequency component and determining the dominant system time constant as a factor of the corner frequency.

8. The method of claim 7, wherein determining the corner frequency includes determining a first frequency component with a peak magnitude and determining a further frequency component at which the magnitude of the further frequency component drops to a predetermined factor below the peak magnitude of the first frequency component.

9. The method of claim 1, wherein determining the one or more statistical measures includes fitting the measured data to a sine wave.

10. The method of claim 9, wherein fitting the measured data to a sine wave includes determining first and second parameters of the sine wave based on statistical measures of the process parameter determined from the measured data.

11. The method of claim 10, wherein the first parameter of the sine wave is an offset and the second parameter of the sine wave is a gain.

12. The method of claim 10, wherein determining the first and second parameters of the sine wave includes determining the offset as a mean value of the process parameter and determining the gain based on the difference between a minimum value and a maximum value of the process parameter.

13. The method of claim 10, including using a variable transformation of a mathematical expression of the sine wave that produces a linear expression having third and fourth sine wave parameters associated therewith, producing a set of transformed data points based on the variable transformation, performing a linear regression to fit the transformed data points to the linear expression and determining the third and fourth sine wave parameters based on the linear regression.

14. The method of claim 13, wherein the variable transformation is of the form:

$$z = \frac{Sin^{-1}(y) - a}{b}$$

wherein:

z is a transformed data point;

y is a measured data point;

a is a sine wave offset parameter; and

b is a sine wave gain parameter,

and wherein the linear expression is of the form:

$z(t) = \omega t + \varphi$

wherein:

$z(t)$ is the transformed data point at a time t;

ω is a sine wave periodic frequency parameter; and

φ is a sine wave phase parameter.

15. The method of claim 14, further including applying a variable transformation to produce a further linear expression including the sine wave offset and gain parameters, applying a linear regression to the further linear expression to determine a new set of values for the sine wave offset and gain parameters and determining a new set of values for the sine wave periodic frequency and phase parameters based on the new set of values for the sine wave off set and gain parameters.

16. The method of claim 15, including iteratively determining values for the sine wave offset, gain, periodic frequency and phase parameters until a change in the values for one or more of the sine wave offset, gain, periodic frequency and gain parameters becomes less than a threshold value.

17. The method of claim 1, wherein determining the one or more statistical measures associated with the process parameter includes determining a baseline value of a first statistical measure of the process parameter and determining a further statistical measure of the process parameter from the measured data, and wherein using the one or more statistical measures associated with the process parameter to detect an abnormal situation within the process plant includes comparing the baseline value of the first statistical measure of the process parameter to the further statistical measure of the process parameter to determine the existence of an abnormal situation.

18. The method of claim 17, wherein determining the baseline value of the first statistical measure of the process parameter includes determining the baseline value as a statistical measure of a first set of the measured data, and wherein determining a further statistical measure of the process parameter from the measured data includes determining the further statistical measure of the process parameter from a second set of the measured data.

19. The method of claim 17, wherein determining the baseline value of the first statistical measure of the process parameter includes using a predetermined value of the process parameter as the baseline value of the first statistical measure of the process parameter.

20. The method of claim 17, wherein the process parameter is a differential pressure between two locations in the process plant.

21. The method of claim 20, wherein the differential pressure is a differential pressure between two trays of a distillation column.

22. The method of claim 21, wherein the differential pressure is a differential pressure between two adjacent trays of a distillation column.

23. The method of claim 21, wherein the differential pressure is a differential pressure between two non-adjacent trays of a distillation column.

24. The method of claim 21, wherein the baseline value of the first statistical measure of the process parameter is a low differential pressure value and wherein comparing the baseline value of the first statistical measure of the process parameter to the further statistical measure of the process parameter to determine the existence of an abnormal situation includes detecting tray dumping or tray damage when the further statistical measure of the process parameter is less than the low differential pressure value.

25. The method of claim 21, wherein the baseline value of the first statistical measure of the process parameter is a high differential pressure value and wherein comparing the baseline value of the first statistical measure of the process parameter to the further statistical measure of the process parameter to determine the existence of an abnormal situation includes detecting tray plugging when the further statistical measure is greater than the high differential pressure value.

26. The method of claim 20, wherein the process parameter is a differential pressure across a catalyst valve in a fluid catalytic cracker and wherein comparing the baseline value of the first statistical measure of the process parameter to the further statistical measure of the process parameter to determine the existence of an abnormal situation includes detecting an air blower problem when the mean value of the differential pressure across the catalyst valve is less than the baseline value.

27. The method of claim 20, wherein the process parameter is a differential pressure across a catalyst valve in a fluid catalytic cracker, and wherein comparing the baseline value of the first statistical measure of the process parameter to the further statistical measure of the process parameter to determine the existence of an abnormal situation includes detecting a catalyst flow problem when the standard deviation of the differential pressure across the catalyst valve is greater than the baseline value.

28. The method of claim 20, wherein the process parameter is a differential pressure between a catalyst regenerator and a reactor in a fluid catalytic cracker and wherein comparing the baseline value of the first statistical measure of the process parameter to the further statistical measure of the process parameter to determine the existence of an abnormal situation includes detecting an air flow malfunction when the differential pressure between the catalyst regenerator and the reactor in the fluid catalytic cracker is less than the baseline value.

29. The method of claim 17, wherein the process parameter is a level parameter.

30. The method of claim 29, wherein comparing the baseline value of the first statistical measure of the process parameter to the further statistical measure of the process parameter to determine the existence of an abnormal situation includes detecting pipe plugging when the further statistical measure of the level parameter becomes greater than the baseline value.

31. The method of claim 17, wherein the process parameter includes first and second level parameters and first and second pressure parameters and wherein the further statistical measure of the process parameter is a cross correlation between the first and second level parameters and the first and second pressure parameters and wherein comparing the baseline value of the first statistical measure of the process parameter to the further statistical measure of the process parameter to determine the existence of an abnormal situation includes detecting plugging when the cross correlation between the first and second level parameters and the first and second pressure parameters exceeds the baseline value.

32. The method of claim 17, wherein the process parameter is a temperature parameter.

33. The method of claim 32, wherein the temperature parameter is a temperature in a reactor of a fluid catalytic cracker and wherein comparing the baseline value of the first statistical measure of the process parameter to the further statistical measure of the process parameter to determine the existence of an abnormal situation includes detecting insufficient steam flow when the statistical measure of the temperature in the reactor becomes greater than the baseline value.

34. The method of claim 33, wherein the statistical measure of the temperature in the reactor is a mean value of the temperature in the reactor.

35. The method of claim 32, wherein the temperature parameter is a temperature in a reactor of a fluid catalytic cracker and wherein comparing the baseline value of the first statistical measure of the process parameter to the further statistical measure of the process parameter to determine the existence of an abnormal situation includes detecting thermal extremes when the statistical measure of the temperature in the reactor becomes greater than a first baseline value or less than a second baseline value.

36. The method of claim 17, wherein the process parameter is a differential temperature between two locations of the process plant.

37. The method of claim 36, wherein the process parameter is a differential temperature between two locations of a fluid catalytic cracker and wherein comparing the baseline value of the first statistical measure of the process parameter to the further statistical measure of the process parameter to determine the existence of an abnormal situation includes detecting thermal cracking when the further statistical measure of the differential temperature exceeds the threshold.

38. The method of claim 37, wherein the process parameter is a differential temperature between a reactor and an exhaust pipe of the reactor within the fluid catalytic cracker.

39. A method of detecting an abnormal situation in a fluid catalytic cracker, comprising:

receiving measurements of a process parameter in the fluid catalytic cracker;

determining a statistical measure of the process parameter from the process parameter measurements;

comparing the statistical measure of the process parameter to a baseline value; and

detecting the existence of an abnormal situation based on the comparison of the statistical measure of the process parameter to the baseline value.

40. The method of claim 39, further including determining the baseline value as a predetermined value.

41. The method of claim 39, further including determining the baseline value as a statistical measure of a first set of the measurements of the process parameter.

42. The method of claim 39, wherein the process parameter is a differential pressure between two locations in the fluid catalytic cracker and wherein the statistical measure of the process parameter is a mean of the differential pressure between two locations in the fluid catalytic cracker.

43. The method of claim 39, wherein the process parameter is a differential pressure across a catalyst valve in the fluid catalytic cracker, wherein the statistical measure of the process parameter is a mean of the differential pressure across the catalyst valve in the fluid catalytic cracker and wherein detecting the existence of an abnormal situation based on the comparison of the statistical measure of the process parameter to the baseline value includes detecting an air blower problem when the mean value of the differential pressure across the catalyst valve is less than the baseline value.

44. The method of claim 39, wherein the process parameter is a differential pressure across a catalyst valve in the fluid catalytic cracker, wherein the statistical measure of the process parameter is a standard deviation of the differential pressure across the catalyst valve in the fluid catalytic cracker and wherein detecting the existence of an abnormal situation based on the comparison of the statistical measure of the process parameter to the baseline value includes detecting a catalyst flow problem when the standard deviation of the differential pressure across the catalyst valve is greater than the baseline value.

45. The method of claim 39, wherein the process parameter is a level parameter within the fluid catalytic cracker, wherein the statistical measure of the process parameter is a mean of the level parameter and wherein detecting the existence of an abnormal situation based on the comparison of the statistical measure of the process parameter to the baseline value includes detecting pipe plugging when the mean of the level parameter becomes greater than the baseline value.

46. The method of claim 39, wherein the process parameter includes a first level parameter and a first pressure parameter in a reactor of the fluid catalytic cracker and includes a second level parameter and a second pressure parameter in a regenerator of the fluid catalytic cracker, wherein the statistical measure of the process parameter is a cross correlation between the first and second level parameters and the first and second pressure parameters, and wherein detecting the existence of an abnormal situation based on the comparison of the statistical measure of the process parameter to the baseline value includes detecting pipe plugging between the reactor and the regenerator when the cross correlation changes by a value greater than the baseline value.

47. The method of claim 39, wherein the process parameter is a temperature parameter within the fluid catalytic cracker, wherein the statistical measure of the process parameter is a mean of the temperature parameter and wherein detecting the existence of an abnormal situation based on the comparison of the statistical measure of the process parameter to the baseline value includes detecting insufficient steam flow when the mean of the temperature in the fluid catalytic cracker becomes greater than the baseline value.

48. The method of claim 39, wherein the process parameter is a temperature parameter within the fluid catalytic cracker, wherein the statistical measure of the process parameter is a mean of the temperature parameter and wherein detecting the existence of an abnormal situation based on the comparison of the statistical measure of the process parameter to the baseline value includes detecting thermal extremes when the statistical measure of the temperature in the fluid catalytic cracker becomes greater than a first baseline value or less than a second baseline value.

49. The method of claim 39, wherein the process parameter is a differential temperature within the fluid catalytic cracker, wherein the statistical measure of the process parameter is a mean of the differential temperature and wherein detecting the existence of an abnormal situation based on the comparison of the statistical measure of the process parameter to the baseline value includes detecting thermal cracking when mean of the differential temperature exceeds the baseline value.

50. The method of claim 39, wherein determining the statistical measure of the process parameter from the process parameter measurements, comparing the statistical measure of the process parameter to the baseline value and detecting the existence of the abnormal situation are performed within a field device that detects the measurements of the process parameter.

51. A method of detecting an abnormal situation in a distillation column, comprising:

receiving measurements of a process parameter in the distillation column;

determining a statistical measure of the process parameter from the process parameter measurements;

comparing the statistical measure of the process parameter to a baseline value; and

detecting the existence of an abnormal situation based on the comparison of the statistical measure of the process parameter to the baseline value.

52. The method of claim 51, wherein the differential pressure is a differential pressure between two trays of the distillation column.

53. The method of claim 52, wherein the differential pressure is a differential pressure between two adjacent trays of the distillation column.

54. The method of claim 52, wherein the baseline value is a low differential pressure value, the statistical measure of the process parameter is a mean of the differential pressure and wherein detecting the existence of an abnormal situation includes detecting tray dumping or tray damage when the mean of the differential pressure is less than the low differential pressure value.

55. The method of claim 52, wherein the baseline value is a high differential pressure value, the statistical measure of the process parameter is a mean of the differential pressure and wherein detecting the existence of an abnormal situation includes detecting tray plugging when the mean of the differential pressure is greater than the high differential pressure value.

56. The method of claim 52, wherein determining the statistical measure of the process parameter from the process parameter measurements, comparing the statistical measure of the process parameter to the baseline value and detecting the existence of the abnormal situation are performed within a field device that detects the measurements of the process parameter.

57. A method of processing data collected in a process plant, comprising:

using a first set of the collected data points to determine a block length for calculating one or more statistical measures of the collected data including;

determining a frequency component of the first set of the collected data points,

determining a dominant system time constant from the frequency component; and

setting the block length based on the dominant system time constant; and

using the block length to determine a number of data points to use in calculating the one or more statistical measures of the collected data.

58. The method of claim 57, wherein determining the frequency component includes performing a Fourier Transform on the first set of collected data points.

59. The method of claim 57, wherein setting the block length includes selecting the block length as a multiple of the dominant system time constant.

60. The method of claim 57, wherein determining the dominant system time constant includes determining a corner frequency from the frequency component and determining the dominant system time constant as a factor of the corner frequency.

61. The method of claim 57, wherein using the first set of the collected data points to determine the block length and using the block length to determine the number of data points to use in calculating the one or more statistical measures of the collected data are performed within a field device that performs measurements to produce the data collected in the process plant.

62. A method of fitting a sine wave to data collected within a process plant, comprising:

determining a first set of parameters of the sine wave based on one or more statistical measures of the process parameter determined from the data collected within the process plant;

storing a variable transformation of a mathematical expression of the sine wave that produces a linear expression having a second set of sine wave parameters associated therewith;

using the variable transformation to produce a set of transformed data points from the data collected within the process plant;

performing a linear regression to fit the transformed data points to the linear expression; and

determining the second set of sine wave parameters based on the linear regression.

63. The method of claim 62, wherein the first set of parameters of the sine wave includes an offset and a gain.

64. The method of claim 63, wherein determining the first set of parameters of the sine wave includes determining the offset as a mean value of the data collected within the process plant and determining the gain based on the difference between a minimum value and a maximum value of the data collected within the process plant.

65. The method of claim 63, wherein the second set of parameters of the sine wave includes a cyclic frequency and a phase.

66. The method of claim 63, wherein the variable transformation is of the form:

$$z = \frac{Sin^{-1}(y) - a}{b}$$

wherein:

z is a transformed data point;

y is a collected data point;

a is the offset; and

b is the gain,

and wherein the linear expression is of the form:

$z(t) = \omega t + \varphi$

wherein:

z(t) is the transformed data point at a time t;

ω is a periodic frequency; and

φ is a phase.

67. The method of claim 66, further including applying a variable transformation to produce a further linear expression including the offset and the gain, applying a linear regression to the further linear expression to determine a new set of values for the offset and the gain and determining a new set of values for the periodic frequency and the phase based on the new set of values for the offset and the gain.

68. The method of claim 67, including iteratively determining values for the sine wave offset, gain, periodic frequency and phase until a change in the values for one or more of the sine wave offset, gain, periodic frequency and phase becomes less than one or more threshold values.

69. The method of claim 62, wherein determining the first set of parameters of the sine wave, using the variable transformation, performing the linear regression and determining the second set of sine wave parameters are performed in a device that collects or measures the data collected within the process plant.